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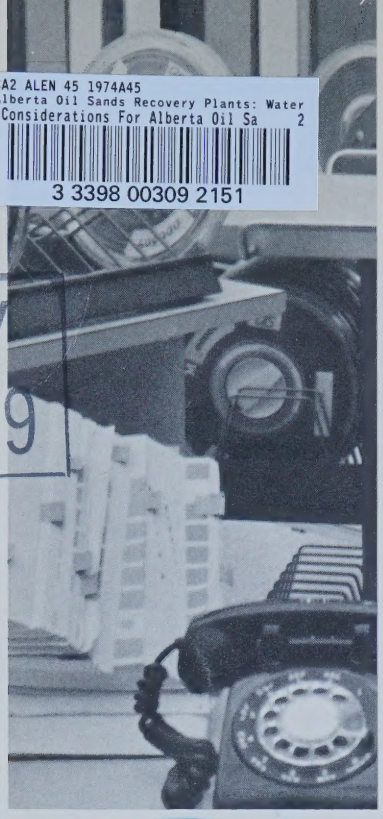

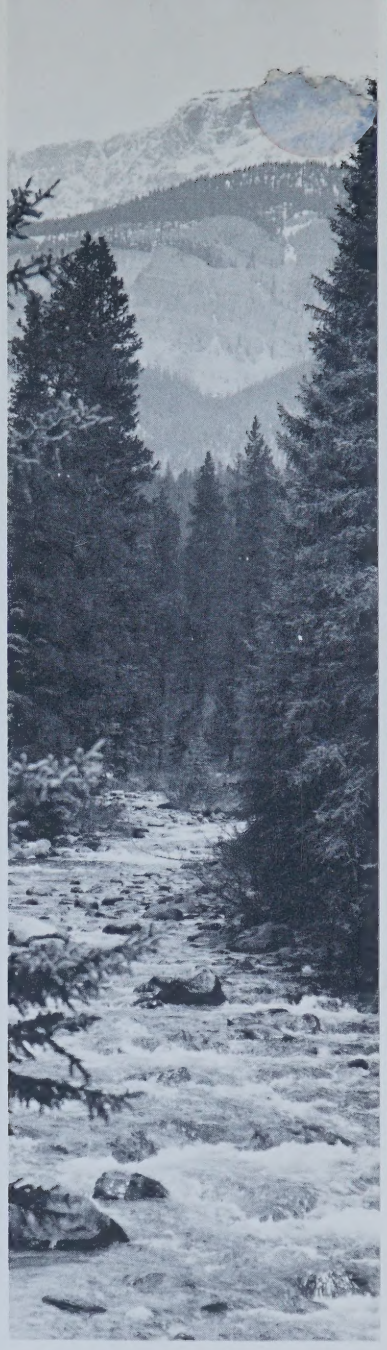

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WATER CONSIDERATIONS FOR ALBERTA OIL SANDS DEVELOPMENTS

SEPTEMBER 26, 1974

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WATER CONSIDERATIONS FOR ALBERTA OIL SANDS DEVELOPMENTS

SEPTEMBER 26, 1974

ALBERTA OIL SANDS

RECOVERY PLANTS

WATER CONSIDERATIONS FOR

ALBERTA OIL SANDS DEVELOPMENTS

by

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Environmental Protection Service

Department of Environment

September 26, 1974

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ABSTRACT

The Athabasca River watershed comprises a vital part of the northern Alberta ecological system and will provide the principal source of water for oil sands project developments. Water requirements are related to the extent of development of the bituminous sands and the type of process used in the separation of bitumen from the sand. Open pit surface mining techniques and the Clark hot water separation process represents demonstrated technology which will be fundamental to the first generation oil sands recovery activities. In association with this technology, the consumptive use of water from the Athabasca River at a production level of one million barrels per calendar day of synthetic crude oil will amount to 350 cubic feet per second. This estimate is based on maximum recycling of waste waters from tailings ponds of extensive aerial extent to the extraction plants and also represents ten percent of the minimum monthly average flow in the Athabasca River. The waste water management concept for new oil sands recovery plants is to impound all water in perpetiuty and to maximize the re-use of process waste waters originating from the mining pit area, the extraction and bitumen upgrading plants and the utilities plants and to control surface run-off.

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1.0 INTRODUCTION

One of the prime factors to be considered in the development of the Alberta oil sands is water. The availability of sufficient quantities of water, the volumes and quality of waste waters, the method of disposal of all plant waste waters, and the effect on the environment are of concern. The purpose of this report is to:

(a) describe an exemplary oil sands recovery plant in association with its standard process units and waste water sources;

(b) discuss projected water usage relative to production of synthetic crude oil from oil sands by application of current commercial technology; and

(c) provide an overview of the proposed methods of managing waste waters which originate from the extraction plant, bitumen upgrading plant, utility plant, mine pit area and natural precipitation.

1.1 Major Oil Sands Developments

To date, applications for approval of construction and operation of new major oil sands projects have been registered by four consortiums: Syncrude Canada Ltd. Mildred Lake Project (125,000 barrels of synthetic crude oil per calendar day - BPCD), Shell Canada Ltd. (100,000 BPCD), Petrofina Canada Ltd. (122,500 BPCD) and Home Oil Company Ltd. (103,000 BPCD). The existing Great Canadian Oil Sands plant at Tar Island began operations in 1967 and current plans are to increase production to 65,000 BPCD by maximizing the efficiency of several process units. Therefore, it is expected that the productive capacity of these five mining projects will be in the order of 515,500 BPCD by 1985.

1.2 Experimental In-Situ Projects

Eight oil companies are currently carrying out separate experimental field projects to produce oil from a wide range of deeply buried oil sands deposits at Cold Lake and Athabasca in the east to Peace River in the west. These projects generally attempt to recover oil from heavy oil deposits (buried at a depth beyond the economic reach of mining) through the application of heat, i.e., steam injection or underground combustion followed by waterflooding. Should these programs prove successful, applications may be registered for approval of commercial schemes of 100,000 BPCD capacity units in the early 1980's.

2.0 EXEMPLARY OIL SANDS PLANT

2.1 General Description

All of the new major proposals for the recovery of synthetic crude oil from the sands are based on a refinement of the principles of current technology which has been demonstrated by the existing Great Canadian Oil Sands plant. The methods proposed for mining and processing synthetic crude oil are briefly summarized as follows:

(a) Preconstruction activity related to ground water hydrology studies and pump tests to determine the locality and extent of local aquifers.

(b) Diversion of creeks which overlay active mining sites or tailings ponds sites.

(c) Muskeg drainage and removal.

(d) Overburden stripping by bucket wheel excavators.

(e) Mining orebody by bucket wheel excavators. Overburden and reject material will be conveyed to a tailings pond for dike building or to the mined out area for disposal.

(f) Oil sand transportation by multiple belt conveyors to a surge storage bin from where it will be fed to the extraction plant for recovery of bitumen.

(g) Bitumen extraction by the Clark hot water extraction process to separate the bitumen from the sand. Process steps will include hot water conditioning of the ore, settling, froth flotation and naphtha dilution centrifuging, followed by recovery of the naphtha from the bitumen by distillation. Tailings from the extraction plant will be discharged to a tailings pond for settling and eventual water recycle.

(h) Upgrading of raw bitumen to produce a low sulphur, 30° API synthetic crude.

i) Primary upgrading - fluid coking, a conventional proven petroleum refining technique will be adapted to produce naphtha, liquid gas oil, gaseous products and coke. The major source of waste water in the coking process is the overhead accumulator on the fractionator, where water is separated from the hydrocarbon vapor and sent to the sewer system. This water usually contains various oil and fractions and may be high in five-day biochemical oxygen demand, chemical oxygen demand, ammonia, phenol, and sulfides and may have a high alkalinity.

ii) Secondary upgrading - hydrogen treating of the liquid products for sulphur and nitrogen reduction and blending with product butanes to produce the synthetic crude product. The strength and quantity of waste waters generated by hydrotreating depends upon the sub-process used and feedstock. Ammonia and sulfides are the primary contaminants, but phenols may also be present.

(i) Sour water strippers reduce the hydrogen sulfide and ammonia content of sour water which is produced by the fluid coker and hydrotreaters. The effluent water will flow to an API oil-water separator and be recycled to the tailings pond for re-use.

(j) Sulphur production by Claus plant and tail gas clean-up. The gaseous products from the upgrading plant will be desulphurized in an amine treating unit and fractionated to provide hydrogen plant feed. The hydrogen sulfide rich gas from the amine treating units and the sour water stripper will be the feed stock for the sulphur recovery plant.

(k) Stack gas clean-up by electrostatic precipitators and sulphur reduction of exhaust gases resulting from the combustion of surplus coke which will be used for plant fuel.

(l) Transportation of synthetic crude product by pipeline to enter the major pipeline distribution networks. Intermediate and product storage facilities will be installed.

(m) Auxiliary facilities will include hydrogen production and steam generation and electric power by the utilities plant.

(n) All fuel requirements except for start-up and emergencies will be satisfied from within the complex.

(o) *Make-up water requirements will be minimized by maximum water re-use. The entire system will be designed on the basis that no waste waters will be returned to the Athabasca River.*

2.2 Water Requirements

2.2.1 Water Supply System

Raw make-up water to the plant will be supplied from the Athabasca River into an adjacent sedimentation pond which will function as a raw water reservoir. Treated raw water will be used to supply cooling water

and boiler feed water make-up, potable water and chemical dilution water. Untreated raw water will be used to supply recycle process water make-up, utility water, gland water and firewater.

2.2.2 Extraction Plant Tailings

The conventional technique for recovering the bitumen from the oil sands by exemplary plants is by extraction with hot water. Initially, this involves mixing approximately one ton of water per ton of oil sands in the extraction plant. All of the liquid wastes from the extraction plant contain mineral solids. This effluent source is hydraulically transported as 50% solids to a tailings pond disposal area before mined out areas become available for storage. Efficient tailings and water management is required to minimize usage of fresh water. Tailings sand is used for dike construction, and some water becomes bound up in the sand voids and remains trapped. As well, a clay suspension or sludge forms at the pond bottom which, due to high mineral content, is unsuitable for recycle to the extraction plant. Above this sludge, a layer of settled water is maintained of sufficient depth to permit continuous recycle without entrainment of solids. The recycling of this partly clarified water will commence approximately three years after plant start-up and when the solids in the supernatant layer of the tailings pond have settled out to less than three percent by weight. Water will be reclaimed by pumps mounted on a floating barge and recycled to the extraction plant to the extent of 50 - 60% of the initial water consumptive rate during plant start-up. An advantage of recycling tailings pond water is that the water demand for steady state plant operations is reduced by 50% (.5 tons water per ton of oil sands feed). The total water requirements of one

exemplary plant producing 125,000 BPCD of synthetic crude will amount to 43 cubic feet per second. The aggregate water requirements of 8 plants producing one million BPCD and the relatively minor demands for increased municipal requirements will amount to 350 cubic feet per second. The Athabasca River is the principal source of water for oil sands project developments and this projected water demand represents 10% of the minimum monthly average flow (3731 cfs - February, 1964).

Since mean annual monthly flows are in the order of 18,000 cubic feet per second, this water withdrawal may have little effect on river characteristics which depend on average or maximum flow rates. Additional insight in this area of concern may be provided by a contract study which was announced on March 15, 1974 and is being co-sponsored by the Department of the Environment and the Energy Resources Conservation Board. The study relates to preliminary evaluation of potential hydroelectric development sites on the Athabasca River. One area of review under this study will be the identification of possible benefits for recreation and waterflood control, municipal and industrial water supply, and determination of upstream and downstream affects and implications of a dam at the recommended site.

2.3 Tailings Pond Design

Tailings ponds will be of extensive aerial extent, ranging from six to ten square miles, and will be adequately designed to receive all liquid effluent streams originating from the plant operations. These waste waters include the following sources:

(a) mine pit ground water;

(b) extraction plant;

(c) bitumen upgrading plant (oily water sewer, sour water stripper and API oil-water separator and Biox treater effluents);

(d) treated sanitary wastes (effluent from permanent sewage treatment plant which is combined with polishing pond);

(e) utilities plant (cooling tower and boiler water blowdown).

Seepage through the dikes will be controlled by the use of continuous internal gravel filters, and will be monitored by piezometers. The seepage will reduce with time as voids in the sands are sealed by sludge fines.

The ultimate height of the dikes is governed by the rate of development of the mine pit. The life of the main tailings pond, its areas and volumes at various elevations, and rate of construction of the dikes necessary to keep the crests well above the rising pond level will be closely monitored. This is necessary to corroborate the water balance calculations which have been estimated for the current oil sands proposals.

The Great Canadian Oil Sands plant differs from exemplary plant proposals in that the upgrading waste waters are treated prior to discharge to the Athabasca River in accordance with effluent standards prescribed by the Alberta Department of the Environment rather than discharge to the mine pit area. The controlled discharge of treated waste waters to the Athabasca River may in part have been necessitated by early mechanical problems relating to pioneer mining technology, slow tailing settling rates and sand disposal difficulties. Most of the mechanical problems have been overcome and progress is being made to review and improve the settling rate of the fines and reduce the volume of waste material to be handled. New plants will be required to accurately monitor the tailings pond water balance in reference to the planned mining schedule. It will be necessary to ensure and confirm the principles of maximum recycle of tailings pond water to the extraction plant and clearly demonstrate

the zero discharge concept of isolating all process waste waters from direct or indirect entry to the Athabasca River.

2.3.1 Tailings to Mine Pit

As soon as it is feasible to do so, the extraction plant tailings will be discharged into the mine pit. The timing is dependent upon the method employed to open the pit and the volume of the excavated pit - to avoid interfering with the mining operation.

The currently planned method of opening the mine indicates that the earliest time tailings can be economically placed will be about six years from start-up. Sludge water will then be returned to the main tailings pond.

One of the problems associated with reclamation of a tar sands mine is that the residual solids and associated waters will occupy a volume up to 30 percent greater than the void space created by the mining operation. As a consequence of this volumetric swelling, the final elevation of the reclaimed mine area could be up to 100 feet higher than the surrounding terrain.

2.4 Water Balance

Pumped water requirements of the extraction and upgrading complexes are to be served by an integrated system and will be supplied in nearly equal portions of river and reclaimed waters.

The need for make-up water is governed by three mechanisms:

i) processing losses to the atmosphere;

ii) losses due to water held in the coarse sand tailings and pond bottom sludges;

iii) natural losses to percolation, evaporation and precipitation gains.

There are a number of factors which can govern a particular balance; usually as related to the amount of free water available for recycle from the tailings pond. Principal factors are:

(a) Mine ground water; quality determines if useable as part of reclaim water circuit.

(b) Net balance of natural evaporation vs. precipitation within the tailings impounding area. (Thermal evaporation will tend to be proportional to production).

(c) Precipitation run-off to recycle and raw water retention ponds from surrounding drainage areas.

(d) Sludge compaction; as hydrostatic head increases with the rising pond level, bottom sludges densify thus releasing free water. Expected maximum densification is 40 percent solids by weight.

(e) Percent of sludge forming silts and clays present in the freshly mined tar sands.

(f) Bottom percolation - this mechanism tends to decrease, perhaps almost stopping, with time, as sludge fines seal off the pond bottom.

(g) Atmospheric losses from cooling towers.

2.5 Surface Run-off

(1) Mining Area - surface run-off in the mining area will be collected in interception ditches and discharged by gravity flow into one of the water supply retention ponds.

(2) Extraction and Upgrading Plant - direct precipitation on process and sulphur block storage areas to be collected, controlled and ultimately directed to the main tailings pond.

3.0 IN-SITU PLANT

3.1 Water Requirements

In-situ methods will result in water displacing about 60% of the bitumen in place. Since the bitumen will be recovered as a water emulsion, the same consideration of liquid tailings for exemplary plants using the hot water extraction method will apply. A steam injection system for one million BPCD of bitumen production would utilize 362 cubic feet per second of water demand and constraints will be in order to ensure maximum recycling of water. This is similar to exemplary plant proposals.

4.0 WASTE WATER MANAGEMENT PRINCIPLES

An outline of basic waste water management principles as these apply to oil sands developments under the Alberta Clean Water Act may be referred to in the Syncrude Criteria document prepared by the Department of the Environment in January, 1973. The availability of large land areas which are leased by the oil sands developers permit the construction of large settling ponds for the total containment, recycle and re-use of waste waters. The waste water management concept for new oil sands recovery plants is to impound all water in perpetuity and to maximize the re-use of process waste waters originating from the mining pit area, the extraction and bitumen upgrading plants and the utilities plant and to control surface run-off.

5.0 CONCLUSIONS

New oil sands recovery plants of the early 1980's will be generally operated in accordance with the fundamentals of demonstrated commercial technology. This current technology consists of open pit surface mining techniques and the Clark hot water separation process. In association

with this mode of operation, the consumptive use of water supplies from the Athabasca River is estimated to be 350 cubic feet per second per one million barrels of synthetic crude oil produced per calendar day. Preliminary calculations also indicate that a similar water demand may apply for development of commercial in-situ recovery systems. The waste water management concept for new oil sands recovery plants is to maximize the re-use of all process waters by containment and recycling within the lease boundary.